Subsurface Prospecting by Planetary Drones, Phase II

Completed Technology Project (2016 - 2021)

Project Introduction

Recurring slope linae (RSL), such as those in Newton Crater on Mars, methane plumes in hazardous Martian terrain, and water ice discovered during the LCROSS experiment in the Moon?s permanently shadowed Cabeus Crater drive the need for a new generation of robotic explorers that access, probe, extract, and return resources from extreme terrains. These robots must possess sufficient system-level autonomy to operate without human guidance due to latency constraints over vast distances, and must also have perceptual capabilities to analyze sensor measurements and the belief state to make decisions about where to explore and whether a target is worth sampling. This enhanced exploration capability takes advantage of perceptual models that can encode the probability of the existence of a resource given material properties estimated from current and prior sensor measurements. The proposed program innovates novel perceptual models and exploration algorithms that maximize the likelihood of detecting resources if they are present and enables robots to make decisions about where to loiter in order to sample terrain for a particular resource. Beyond topical research, the program will ruggedize Phase 1 software to operate in the presence of sensor and state uncertainty, integrate the capabilities on physical robots, and demonstrate results in relevant, subterranean field test. Besides RSL and craters, the research enables exploration and access of cryovolcanoes, steep and deep gullies, and canyons. Terrestrial applications include the detection of radiation in contaminated facilities or explosive gases and flammable dust in mines, surveying urban canyons, and exploring bunkers and caves.

Anticipated Benefits

Aerial prospecting enables future missions to rapidly explore and quantify localized resources such as peaks of persistent light, planetary caves, and volatile-rich regions. This program delivers guidance and algorithms for precision safe landing and maneuvering. The immediate markets within NASA are for exploration and science missions to surface destinations on the Moon, Mars, and asteroids. Phase II development occurs in the context of a mission to the Moon and Mars. The technologies are enabling for future missions that prospect by rover, but the principles apply to precise touchdown and is applicable to near term missions such as Mars 2020, RP, and Asteroid Redirect. The proposed innovations in guidance improve mission capability by enhancing landing precision, enabling access to previously inaccessible terrain, providing accurate autonomous target-relative navigation, modeling a target on board a spacecraft; and providing a light weight, power efficient solution to TRN. This capability enables robotic exploration of areas with the highest scienti?c value and future human exploration.? The RP, currently in Phase A with a target launch in 2019, has a $250M budget reserved. Science return is dependent on landing in an identi?ed region with high volatile content and near regions of permanent dark. Polar terrain on the Moon is hazardous and lighting varies locally, so precise landing relative to terrain is critical.The

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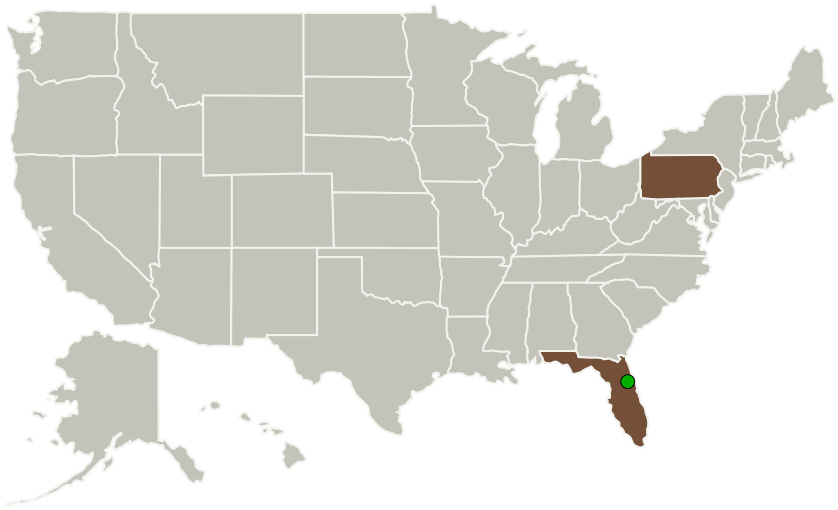
techniques developed under this contract for autonmous survey, detection, and mapping have significant opportunity in the commercial sector. Markets are as varied as First Responder (emergency response data gathering) to Survey Equipment. There are other emerging markets that are not mature enough to demand trending attention such as tower inspections (electric transmission lines, wind turbines, cell phone towers), in-construction building progress inspections, indoor arena ceiling/roof structure/lighting inspections), train and auto tunnel inspections and any need for data, visual and otherwise, from locations difficult, dangerous or impossible to access via foot traffic or vehicles. The technology will be broadly applicable to resource prospecting in cold traps, dark craters, cryovolcanoes, asteroids, comets, and other planets. The technology is also applicable to Earth-relevant problems such as the detection of poisonous and explosive gases and flammable dust in mines; surveying urban canyons; and exploring bunkers and caves.Law Enforcement, First Responder, Search and Rescue will bene?t from this technologyon robots that are being used to keep personnel out of harm's way. Examples are investigating damaged buildings where volatile liquid or other dangerous substances may be present, search and rescue where autonomous navigation with characterization would potentially allow lost person recognition from a ground or airborne unmanned vehicle

Primary U.S. Work Locations and Key Partners



Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Lead Organization:

Astrobotic Technology, Inc.

Responsible Program:

Small Business Innovation Research/Small Business Tech Transfer

Project Management

Program Director:

Jason L Kessler

Program Manager:

Carlos Torrez

Project Managers:

Michael E Vinje
Tom Ebert

Principal Investigator:

Andrew Horchler

Co-Investigator:

Nathan Michael

Small Business Innovation Research/Small Business Tech Transfer

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Organizations Performing Work	Role	Type	Location
Astrobotic Technology, Inc.	Lead Organization	Industry	Pittsburgh, Pennsylvania
Kennedy Space Center(KSC)	Supporting Organization	NASA Center	Kennedy Space Center, Florida

Primary U.S. Work Locations	
Florida	Pennsylvania

Project Transitions

September 2016: Project Start

June 2021: Closed out

Closeout Documentation:

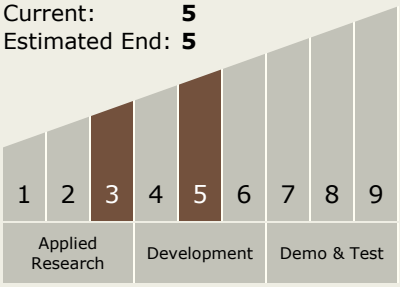
- Final Summary Chart PDF*(https://techport.nasa.gov/file/137350)*

Images

Briefing Chart Image
Subsurface Prospecting by Planetary Drones, Phase II
(https://techport.nasa.gov/image/130647)

Technology Maturity (TRL)

Start: **3**
Current: **5**
Estimated End: **5**



Target Destinations

The Sun, Earth, The Moon, Mars, Others Inside the Solar System, Outside the Solar System